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VI

CLIMATE AND ITS INFLUENCE UPON THE OLIGOCENE FAUNAS OF THE PACIFIC COAST, WITH DESCRIPTIONS OF SOME NEW SPECIES FROM THE MOLOPOPHORUS LINCOLNENSIS ZONE\*

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#### INTRODUCTION AND ACKNOWLEDGMENTS

Our knowledge of the Oligocene of the Pacific Coast is very inadequate. In order that we may study the Oligocene, its fauna must be first described. The descriptions of 36 new species from a fauna of 48 specifically identifiable forms obtained from a single locality are given below. Better testimony concerning our ignorance of the Oligocene could hardly be given when the discovery of a new locality by two such good collectors and enthusiastic paleontologists as Mr. F. M. Anderson and Mr. Bruce Martin results in finding a fauna which is 75 per cent new.

The fauna described in this paper was obtained from near Vader, Washington, on the Cowlitz River, by Mr. F. M. Anderson and Mr. Bruce Martin, the Curator and Assistant Curator, respectively, of the Department of Paleontology of the California Academy of Sciences. Mr. Martin describes

the locality and incidental stratigraphy as follows: "Locality 181, on the east bank of the Cowlitz River just back of the Greeco ranch house, about four miles east of Vader, Washington. There appear to be two formations represented at this point. The fossils occur in a sandstone formation which is associated with a conglomerate. The upper zone which is mostly *Ostrea* is in a conglomerate composed of basalt pebbles and boulders. The lower zone is nearly all small gastropods which occur in blue sandstone. These two beds dip northwest at a very small angle—about  $0^{\circ}$ - $5^{\circ}$ . A few yards to the south, a well stratified, coarse, gray, compact sandstone is exposed dipping south at an angle of  $10^{\circ}$  and striking N.  $70^{\circ}$  E. This sandstone is probably Eocene. About 20 feet south of the fossil beds a mass of coarse conglomerate is butting perpendicularly against the sand to the south. This conglomerate appears to be the same as that where the fossils occur."

The matrix in which this fauna occurs is much coarser than most of the fossil bearing rocks of the Oligocene, which are, in general, shaly in this region. Perhaps it may be that Martin has described an unconformity between Oligocene strata and the Tejon-Eocene rather than a fault.

#### FAUNA

The fauna collected by Messrs. Anderson and Martin is particularly rich in tropical species and the number of species found at one locality—48—is large. This fauna is listed below.

#### LIST OF SPECIES FROM CALIFORNIA ACADEMY OF SCIENCES LOCALITY 181

- Astarte perrini*, new species.
- Arca washingtoniana*, new species.
- Barbatia gabbi*, new species.
- Cardium lincolnensis* Weaver.
- Cardita weaveri*, new species.
- Chama pacifica*, new species.
- Corbula cowlitzensis*, new species.

- Diplodonta dalli, new species.  
Glycimeris andersoni, new species.  
Lima bella, new species.  
Leda merriami, new species.  
Leda washingtonensis Weaver.  
Ostrea lincolnensis Weaver.  
Psammobia martini, new species.  
Pecten branneri Arnold.  
Pitaria clarki, new species.  
Saxicava arnoldi, new species.  
Saxicava, species.  
Semele reagani, new species.  
Semele gayi Arnold.  
Spisula packardi, new species.  
Solen lincolnensis Weaver.  
Tellina obruta Conrad.  
Tellina oregonensis Conrad.  
Acmæa simplex, new species.  
Actæon parvum, new species.  
Conus ruckmani, new species.  
Crepidula, species.  
Cerithiopsis howardi, new species.  
Epitonium washingtonensis Weaver.  
Epitonium merriami, new species.  
Epitonium condoni Dall.  
Exilia weaveri, new species.  
Eulima clarki, new species.  
Fusinus gesteri, new species.  
Fasciolaria gabbi, new species.  
Galeodea dalli, new species.  
Haminea cf. petrosa (Conrad).  
Hipponyx ornata, new species.  
Hipponyx arnoldi, new species.  
Littorina oligocena, new species.  
Marginella pacifica, new species.  
Murex vaughani, new species.  
Molopophorus stephensoni, new species.  
Molopophorus, species.  
Neverita nomlandi, new species.  
Nyctilochus, species a.

Nyctilochus, species b.  
Patella subquadrata, new species.  
Seraphs andersoni, new species.  
Strepsidura packi, new species.  
Surcula dickersoni (Weaver).  
Triforis martini, new species.

Of these forms, *Epitonium washingtonensis* Weaver, *Epitonium condoni* Dall, *Surcula dickersoni* (Weaver), *Cardium lincolnensis* Weaver, *Leda washingtonensis* Weaver, *Ostrea lincolnensis* Weaver, *Semele gayi* Arnold, *Solen lincolnensis* Weaver are characteristic of the Molopophorus lincolnensis zone or Lincoln horizon of Weaver.<sup>1</sup> In addition to these previously described forms, *Neverita nomlandi*, new species and *Galeodea dalli*, new species, occur at Pittsburg Bluffs, Oregon, California Academy of Sciences Locality 163; *Barbatia gabbi*, new species, at California Academy of Sciences Locality 165, two and one-half miles southwest of Clatskanie, Oregon; *Pitaria clarki*, new species, and *Actæon parvum*, new species, at California Academy of Sciences Locality 166, near Clatskanie, Oregon; *Spisula packardi*, new species, in the Oligocene of San Emigdio, California. All of these localities mentioned belong to Weaver's Molopophorus lincolnensis zone. *Haminea petrosa* Conrad, *Tellina obruta* Conrad, *Tellina oregonensis* Conrad, *Pecten branneri* Arnold are other species which range throughout the Oligocene of Washington. This fauna does not contain any of the characteristic species of Weaver's middle and upper Oligocene,—*Turritella portersensis* and *Acila gettysburgensis* zones—or the Twin River and Seattle formations of Arnold and Hannibal,<sup>2</sup> which are really zonal designations, not formational—the equivalents of the *Acila gettysburgensis* zone and, in part, the *Turritella portersensis* zone of Weaver.

No Tejon species occur in this fauna, yet its general cast is eocenic and some of the species such as *Exilia weaveri*, *Galeodea dalli*, *Neverita nomlandi*, *Triforis martini*, *Solen lincolnensis*, are apparently congeneric with forms found in

<sup>1</sup> Weaver, C. E., Tertiary Faunal Horizons of Western Washington, Univ. Wash. Publ. vol. 1, no. 1, pp. 4-6, 1916.

<sup>2</sup> Arnold, R., and Hannibal, H. The Marine Tertiary Stratigraphy of the North Pacific Coast of America, Proc. Amer. Phil. Soc., vol. 52, pp. 579-585, 1913.

the Tejon Eocene of the Cowlitz River, Washington. Likewise no living forms are contained in this fauna.

The character of the sediments and the abundance of *Hipponyx ornata*, *Hipponyx arnoldi*, *Patella subquadrata*, *Crepidula*, sp. and *Acmaea simplex*, sessile shore forms, mark this fauna as a strictly littoral one. In conclusion the fauna appears to belong to a lower facies of the Molopophorus lincolnensis zone of Weaver, and its distinctiveness is due in part to its strictly littoral character and in part to having lived in a portion of Oligocene time older than that of the typical Molopophorus lincolnensis zone.

#### CLIMATIC CONDITIONS DURING LOWER OLIGOCENE TIME

The presence of the genera *Actæon*, *Conus*, *Epitonium*, *Exilia*, *Fasciolaria*, *Marginella*, *Scraphs*, *Strepsidura*, *Barbatia* and *Lima* mark this fauna as subtropical. This character is in accord with the assignment of this fauna to the Molopophorus lincolnensis zone, the San Lorenzo of Arnold and Hannibal<sup>3</sup>, who inferentially recognized the tropical character of the Lower Oligocene. Their statement concerning the climatic conditions in the description of their Seattle formation is given as follows: "In the sections at Gettysburg, Bainbridge Island, Lincoln, Nasel River, Nehalem River, Yaquina River and several other points, the San Lorenzo formation is overlain conformably by a succession of beds usually finer grained, thinner bedded, and more calcareous, though the exceptions are too numerous to mention; containing a rather different fauna of less distinctly tropical type and a forerunner of the boreal Twin River fauna which succeeded it."

Weaver has shown that the Twin River formation is non-existent by a careful stratigraphic survey which connects these beds as one limb of a syncline with beds which Arnold and Hannibal regarded as Seattle. A study of Weaver's faunal zones, the Molopophorus lincolnensis zone, the Turritella porterensis zone and the Acila gettysburgensis zone, seems to indicate that the upper and lower zones contain very distinctive forms, but that the middle zone is transitional although more

<sup>3</sup> Arnold, R., and Hannibal, H. The Marine Tertiary Stratigraphy of the North Pacific Coast of America, Proc. Amer. Phil. Soc., vol. 52, p. 582, 1913.

closely related to the *Molopophorus lincolnensis* zone than to the upper, the *Acila gettysburgensis* zone.

Weaver<sup>4</sup> described the faunal characters of this last zone as follows: "The most characteristic species of the *Acila gettysburgensis* zone are *Acila gettysburgensis* Reagan, *Macrocallista vespertina* (Conrad), *Marcia oregonensis* (Conrad), *Modiolus rectus* Dall, *Panope generosum* (Gould), *Phacoides acutilineatus* (Conrad), *Spisula albaria* (Conrad), *Solemya ventricosta* Conrad, *Tellina oregonensis* Conrad, *Thracia trap-ezoidea* Conrad, *Thyasira bisecta* (Conrad), *Crepidula prærupta* Conrad, *Eudolium petrosum* (Conrad), *Mioleionea indurata* (Conrad), *Turricula washingtoniana* Dall and *Turritella blakeleyensis* Weaver. Such species as *Acila gettysburgensis* Reagan, *Solemya ventricosta* Conrad, *Eudolium petrosum* (Conrad) and *Turricula washingtoniana* Dall appear for the first time in this zone. They are always the most common species met with and are entirely absent from the *Turritella porterensis* and *Molopophorus lincolnensis* zones."

Arnold and Hannibal's list from their Seattle horizon is essentially the same. The disappearance of many tropical genera, the introduction of several temperate genera, are noteworthy temperate faunal conditions. That the *Turritella porterensis* zone was tropical or semi-tropical is well attested by the occurrence of the reef-building coral, *Dendrophyllia hannibali* Nomland and other tropical genera. All the known facts considered, we may then conclude that the *Molopophorus lincolnensis* and *Turritella porterensis* zones were deposited under tropical or subtropical conditions and the *Acila gettysburgensis* zone, under temperate conditions somewhat warmer than those of today in that latitude. What was the reason for this faunal change? May we invoke the great god Diastrophism to aid us in explanation? Probably a depression in the vicinity of the Bering region of Alaska occurred at the beginning of the deposition of the *Acila gettysburgensis* zone and cold boreal waters of the Arctic sea brought with them a boreal fauna some of whose members managed to establish themselves in Washington, in some cases even crowding out the native species. The known history of Oligocene vertebrates gives

<sup>4</sup> Weaver, C. E., The Post-Eocene Formations of Western Washington, Proc. Cal. Acad. Sci., Fourth Series, vol. 6, pp. 30-32, 1916.

some decided support to this hypothesis. According to Osborn,<sup>5</sup> the White River Oligocene is very different from the upper Oligocene of the John Day region and further shows distinct Asiatic and European affinities indicating that the Bering portal was closed during Lower Oligocene time. The John Day Oligocene fauna, however, lacks European affinities, thus indicating that the Bering portal was open at this time. That a portion of the John Day is the land laid equivalent of the Upper Marine Oligocene, the *Acila gettysburgensis* zone is a probability.

#### COMPARISON OF THE LOWER OLIGOCENE FAUNA WITH THE TEJON EOCENE FAUNA

The climate during the Tejon, Upper Eocene time on the Pacific Coast was probably about the same as that of Lower Oligocene time as indicated by faunal studies. Now some of the striking things in the Tejon fauna are its general faunal unity, the great range of many of its species, and the great number of species composing it. These all appear to be functions of a tropical climate, for when the recent tropical faunas are studied the large number of genera and species is a characteristic. Dall<sup>6</sup> has stated this as follows: "We may then conclude that that part of the average mollusk fauna which is capable of leaving traces in the shape of fossils, under conditions not greatly differing from those of the present day, if situated in the Arctic or boreal region, would comprise about 250 species, in the cool temperate region about 400 species; in the warm temperate, about 500 species, and in the tropical region not less than 600 species."

A study of Caribbean Miocene (Upper Oligocene of Dall and others) faunas reveals the fact that several highly ornamented gastropods persist to the Recent; *Turris alba* Perry, for example. Again, these Miocene faunas of the Caribbean exhibit a remarkable unity both stratigraphically and geographically. Briefly, then, one of the characteristics of a tropical fauna is the great range of many of its species. This subject can not be discussed at length here but it is introduced to ex-

<sup>5</sup> Osborn, H. F., Cenozoic Mammal Horizons of Western North America, U. S. Geological Survey, Bull. 361, p. 66, 1909.

<sup>6</sup> Dall, W. H., U. S. Geological Survey, Bull. 84, p. 27, 1892.



plain the Tejon faunal conditions. That Tejon time was not short is indicated by great thicknesses of beds bearing its characteristic fauna, by coal beds at different horizons, and by certain faunal conditions which can not be stated briefly.

Since the climatic conditions of the Tejon and Lower Oligocene were much the same, several species common to the two might be expected. Weaver reports *Brachysphingus clarki*, *Leda uvasana*, *Crassatellites washingtoniana*, *Exilia dickersoni*, and *Hemifusus washingtonianus*, as Tejon forms which also occur in the *Molopophorus lincolnensis* zone. This is a very small number and, moreover, further collecting has not increased it. It appears probable that a great interval of erosion occurred between the beds bearing the Upper Eocene and Lower Oligocene faunas and that the Tejon species finished their life course during the time now represented in the rocks by an unconformable contact yet to be discovered.\*

With a subtropical climate during Lower Oligocene (*Molopophorus lincolnensis* and *Turritella porterensis* zones) time, a faunal character similar to that of the Tejon is to be expected. Hence it may be predicted with a fair degree of safety that the number of species composing the Lower Oligocene fauna will be large, the ranges of many of the species very great both stratigraphically and geographically, and that additional collecting will increase the similarity between the *Molopophorus lincolnensis* and the *Turritella porterensis* zones.

#### CONCLUSIONS

(1). The fauna described in this paper represents a lower facies of the *Molopophorus lincolnensis* zone of Weaver.

(2) The climatic conditions during its deposition were subtropical.

(3). The *Molopophorus lincolnensis* and the *Turritella porterensis* zones have as yet been but imperfectly described and their unity is much greater than the temperate fauna of the *Acila gettysburgensis* zone of the Upper Oligocene.

(4). The *Acila gettysburgensis* zone is possibly the correlative of a portion of the Upper John Day Oligocene.

\* Since this was written, Professor C. E. Weaver has announced the occurrence of unconformities in several places in Washington.

## DESCRIPTIONS OF NEW SPECIES

**Leda merriami**, new species

Pl. 27, Figs. 1a and 1b

Shell inflated, resembling *Leda alæformis* Gabb in general shape; acutely rostrate, very inequilateral, very convex; beak prominent, high; anterior slope convex, ascending; posterior slope concave; anterior end bluntly rounded; base arcuate; escutcheon wide, nearly flat; incremental lines numerous, rounded; anterior teeth, 24; posterior teeth, 20 to 23; chondophore sub-umbonal, not projecting.

*Dimensions*:—Length, 30 mm.; height, 22 mm.; convexity, 4.5 mm.

*Type*:—No. 381, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Dr. J. C. Merriam, Professor of Paleontology, University of California, whose guidance and kindly counsel have been a great inspiration to the writer.

**Arca washingtoniana**, new species

Pl. 27, Figs. 2a and 2b

Shell roughly rectangular; small with beautiful beaded radial ribbing; anterior end straight, making right angles with straight hinge line and nearly straight base; posterior extremity, the pointed extension of a marked umbonal ridge which divides the posterior half of the shell into a flat, alate right triangle in its upper third; decoration consists of thirty to forty subequal beaded ribs.

*Dimensions*:—Length, 5 mm.

*Type*:—No. 382, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

**Glycimeris andersoni**, new species

Pl. 27, Figs. 3a, 3b and 3c

Shell inflated equivalve, nearly equilateral; beaks small, base arcuate, meeting straight, anterior slope medially at anterior

end and merging into the convex posterior; dorsal line straight; seven sloping teeth on either side of six nearly vertical smaller teeth which are centrally located on a strong, wide hinge plate.

*Dimensions*.:—Length, 27 mm.; height, 26 mm.; convexity, of right valve of type, 8 mm.

*Type*.:—No. 383 and cotype 384, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Mr. F. M. Anderson, who collected the type.

#### ***Barbatia gabbi*, new species**

Pl. 27, Fig. 4

Shell small, with nearly straight hinge line; ventral margin very broadly rounded; anterior end narrowly rounded; posterior end rounded broadly, meeting the ventral margin at the extremity of a rounded indefinite umbonal slope.

This description is based upon a study of the growth lines of the broken type and checked by a specimen from another locality which shows a complete outline.

*Type*.:—No. 385, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

#### ***Cardita (Carditamera) weaveri*, new species**

Pl. 27, Figs. 5a and 5b

Shell elongate-quadrate, small; hinge plate heavy, typical; rounded, radial beaded ribs cut by somewhat squamose incremental ribs decorating the shell.

*Dimensions*.:—Length, 7.5 mm.; height, 5 mm.

*Type*.:—No. 386, cotype 387, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Dr. C. E. Weaver of the University of Washington.

**Psammobia martini**, new species

Pl. 27, Figs. 7a and 7b

Shell elongate, flat; nearly flat posterior slope meeting disk of shell along a convex umbonal slope; anterior dorsal slope but slightly excavated under beak sloping less steeply than the posterior dorsal margin.

*Dimensions*:—Convexity, 5 mm.

*Type*:—No. 389, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on the east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Mr. Bruce Martin, who collected the type of this species.

**Astarte perrini**, new species

Pl. 27, Figs. 8a and 8b

Shell quadrate with prominent, sharply pointed beak which is one-third of shell length from acutely rounded anterior; posterior margin truncate; ventral margin broadly arcuate; posterior dorsal margin straight with gentle slope from beak to posterior; anterior dorsal slope concave with elongate narrow fairly distinct lunule; escutcheon indefinite.

*Dimensions*:—Length, 15.5 mm.; height, 13 mm.; convexity, 3 mm.

*Type*:—No. 390, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on the east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Professor James Perrin Smith of Stanford University.

**Corbula cowlitzensis**, new species

Pl. 28, Figs. 3a, 3b and 3c

Shell small, thick, equivalve with inconspicuous beak; anterior dorsal margin convex, sloping steeply to an acutely rounded anterior; ventral margin very broadly rounded; posterior slope, a triangular area with apex at beak, nearly flat, shallowly grooved and separated from the rest of the shell by a very sharp ridge which extends from the beak to the posterior end.

*Dimensions*:—Length, 6 mm.; height, 4 mm.; convexity, 2 mm.

*Type*:—No. 391, cotype 392, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

***Pitaria clarki*, new species**

Pl. 28, Figs. 4a, 4b and 4c

Shell ovate, solid, concentrically sulcate; pallial sinus ample, deep, reaching the middle of shell, but slightly ascending; hinge with strong lateral in left valve, weak lateral in right; lunule not deeply impressed, bounded by an incised line, equally divided between the two valves; escutcheon elongate, poorly defined.

This species differs from *Pitaria dalli* Weaver in having a less quadrate and less elongate form, in having acute—not rounded—ribs, and in being less inflated.

*Dimensions*:—Length of left valve, 41 mm.; height of left valve, 36.5 mm.; convexity of left valve, 7 mm.

*Type*:—No. 393, cotype 394, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on the east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader.

Named for Dr. B. L. Clark, Instructor in Paleontology, University of California.

***Spisula packardi*, new species**

Pl. 28, Figs. 5a and 5b

Shell large trigonal, equivalve, nearly equilateral, ventricose, ornamented by numerous fine concentric ridges which are more pronounced and more numerous on the anterior dorsal area than upon other portions of the shell; beaks moderately prominent; anterior dorsal area limited by a distinct ridge extending from the umbo to the anterior extremity; the margin of this area slightly curved; posterior dorsal slope slightly convex, limited by an indistinct ridge which extends from the beak to the base of the shell; anterior extremity more sharply pointed

than the posterior; base very broadly rounded; hinge plate fairly broad; chondophore oblique, shallow, apically roofed by a broad flat spur; left cardinal prominent, high, arms broad, extending from the dorsal to the ventral margin of the plate; ventral sinus, narrow, deep; right cardinal with a prominent anterior arm and with a well developed, but very thin, posterior arm; laminae long, fairly distant from beaks; anterior lateral formed from the margin of the plate, top acute; posterior lateral also with acute top, dorsal and ventral slopes nearly equal; anterior ventral lamina formed from upturned edge of the hinge plate not confluent with the anterior dorsal cardinal arm.

*Dimensions*.—Length, 53 mm.; height, 39 mm.; convexity, 11 mm.

This species has the same general outline as *S. merriami* Packard, but its sculpturing on the anterior dorsal area is different, its posterior less sharply truncated and the laminae more divergent.

*Type*.—No. 395, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader.

Named for Professor Earl L. Packard of the University of Oregon, whose excellent work on West Coast Mactrinæ has made the members of this subfamily very useful to workers in paleontology.

#### **Semele reagani**, new species

Pl. 29, Figs. 1a, 1b, 1c and 1d

Shell medium size with prominent subcentral beak; lunule and escutcheon obscure; anterior dorsal margin slightly concave; posterior dorsal margin straight, sloping to rounded posterior; anterior sub-truncate; a faint umbonal ridge cutting fine rounded, growth lines decorating shell.

*Dimensions*.—Length, 13.5 mm.; height, 12.5 mm.; convexity, 2.5 mm.

*Type*.—No. 396, cotype 397, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the

Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Mr. A. B. Reagan, who described several interesting Oligocene fossils from Washington.

**Saxicava arnoldi**, new species

Pl. 29, Figs. 5a and 5b

Shell small, inflated, with thin shell substance; beaks conspicuous, large, approximate; hinge line nearly straight; anterior and posterior truncated; pronounced, oval gaping posteriorly; base arcuate.

*Dimensions*.:—Length of imperfect type, 12 mm.

*Type*.:—No. 388, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Dr. Ralph Arnold.

**Diplodonta dalli**, new species

Pl. 29, Fig. 8

Shell medium, inflated, nearly equilateral, equivalve; anterior dorsal slope slightly concave beneath small inconspicuous beaks, thin, slightly convex; anterior broadly rounded; ventral margin arcuate; posterior slope nearly straight, sloping steeply to a medial point on posterior half, where it makes well marked angle with the nearly vertical posterior end. A shallow fluting extends from a point near beak to the middle of the straight posterior end. Concentric incremental growth lines decorate the shell.

*Dimensions*.:—Length, 22 mm.; height, 23 mm.; convexity, 7 mm.

*Type*.:—No. 398, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Dr. William Healy Dall, whose great works in Conchology and Invertebrate Paleontology will continue to guide students in these subjects for years to come.

**Chama pacifica**, new species

Pl. 29, Fig. 10

Shell rugose, robust, nearly circular in outline, the height axis being but slightly greater than length; hinge plate heavy, arcuate; dentition obscure; irregular squamose incremental lines decorating the shell.

*Dimensions*.:—Height of imperfect type, 14.5 mm.

*Type*.:—No. 399, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

**Lima bella**, new species

Pl. 29, Fig. 11

Shell small with thin shell substance; ventral margin acutely rounded; posterior margin straight, sloping steeply from narrow straight hinge line; anterior margin broadly arcuate; very fine radial ribs decorating shell.

*Dimensions*.:—Height, 9 mm.; length, 6 mm.

*Type*.:—No. 400, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

**Actæon parvum**, new species

Pl. 29, Figs. 12a and 12b

Shell small, number of whorls probably five; body-whorl cylindrical; decoration consisting of about 20 flat equally spaced spiral lines with peculiarly pitted interspaces; outer lip thin; inner lip slightly incrustated; aperture, narrow above, elongate and widened below.

*Dimensions*.:—Length of broken type, 6 mm.

*Type*.:—No. 401, cotype No. 402, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.



**Exilia weaveri**, new species

Pl. 30, Figs. 1a and 1b

Shell, long, slender, spindle form; number of whorls nine or 10; spire whorls decorated by about 12 sub-equal spiral threads crossed by slightly sinuous growth lines; a nearly central spiral line slightly stronger than rest occurring at widest diameter of each spire whorl; fine beading, a result of the intersection of the two systems of threads further decorating whorls; suture linear, distinct; body-whorl exhibiting sinuous, axial sculpture more prominent than spiral; aperture elongate-oval; canal long, slender; columella nearly smooth.

This form, which is similar to *E. perkinsiana* Cooper of the Tejon-Eocene, differs from this last named species in that the axial ribbing is far less pronounced and spiral lines more numerous.

*Dimensions*:—Length of broken type, 23.5 mm.; width of body-whorl, 7.5 mm.

*Type*:—No. 410, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Grecco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Dr. Charles E. Weaver, whose investigations in Washington have greatly aided workers in paleontology.

**Neverita nomlandi**, new species

Pl. 30, Figs. 2a and 2b

Shell medium in size, very wide, smooth, with nearly spire; spire whorls, minute, flat-sided; body-whorl with a nearly flat upper portion sloping from suture to middle, where whorl becomes more convex; aperture semilunar; outer lip thin; inner lip covered by a callus which is rounded in the umbilical space which it covers—in most cases completely.

*Dimensions*:—Length, 13 mm.; width of body-whorl, 17 mm.

*Type*:—No. 411, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Grecco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Dr. J. O. Nomland of the Geological Department of the Standard Oil Company.

**Murex vaughani**, new species

Pl. 30, Figs. 3a and 3b

Shell small; body whorl marked by five lamella-form flexuous ribs which extend the entire length of the whorl; these ribs developing nodes twisted toward the right at the shoulder, located a short distance below a sinuous suture; aperture oval, above, narrowed, below.

This form has such individual characters that the writer feels but little hesitation in naming it specifically, although only the body-whorl is known.

*Dimensions*:—Length of the body-whorl of type, 12 mm.; width of body-whorl, 11 mm.

*Type*:—No. 412, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Mr. F. E. Vaughan, graduate student at the University of California.

**Fasciolaria gabbi**, new species

Pl. 30, Figs. 4a and 4b

Shell, fusiform with short spire consisting of seven whorls; first three whorls smooth, naticoid; fourth, fifth, sixth and seventh whorls marked by four strong equally spaced spiral lines with one or more intercalary threads, and by 12 axial ribs which give rise to prominent pointed nodes at the intersection of the spiral lines; sides of these whorls nearly flat in outline, sloping steeply to a wavy suture which is bordered by slight collar formed by the first strong spiral line of the next whorl; body-whorl large, rugose, with greatest width one-fourth of whorl length below suture; space below suture slightly concave and marked by about 10 spiral threads; shoulder of whorl marked by a very strong spiral line with three or four threads between it and the next line of almost equal strength; space below second spiral line covered by three spiral lines of moderate strength and by about 25 to 30 threads; 12

axial ribs intersecting these various spiral lines making nodes at crossings; canal long, straight; inner lip slightly incrustated.

*Type*.—No. 413, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

*Dimensions*.—Length, 24 mm.; width of body-whorl, 12 mm.

Named in honor of William Gabb, pioneer paleontologist of California.

#### ***Cerithiopsis howardi*, new species**

Pl. 30, Figs. 6a and 6b

Shell elongate-conic with 11 whorls, the first three smooth nuclear; fourth, fifth, sixth and seventh whorls decorated by 12 axial ribs crossed by three spiral lines, the uppermost being the weakest; rounded nodes at crossings; eighth whorl similarly decorated except that the uppermost spiral line is equal in strength with other two; ninth, tenth and eleventh whorls, exhibiting two more weaker spiral lines bordering upper and lower sutures, which are impressed and slightly wavy; base smooth; outer lip, thin, sharp; canal very short, nearly straight.

*Dimensions*.—Length of type, 7 mm.

*Type*.—No. 415, cotype 416, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Delle Howard Dickerson, whose constant aid has enabled the writer to do this work.

#### ***Epitonium merriami*, new species**

Pl. 30, Figs. 7a and 7b

Shell medium in size; number of whorls unknown; apical angle small, suture, sharp, distinct, linear; each whorl is decorated by three strong spiral lines crossed by about 20 axial ribs parallel to axis; pits between the two ribbing systems rectangular, with shorter dimensions parallel to axis; split rectangles occurring above and below suture.

A cotype shows that the first three nuclear whorls are smooth.

*Dimensions*:—Length of broken type, 13 mm.

*Type*:—No. 417, cotype 418, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Professor J. C. Merriam, of the University of California.

***Galeodea dalli*, new species**

Pl. 30, Figs. 8a and 8b

Shell globose, highly decorated by three rows of rounded nodes on the body-whorl and by wavy spiral lines of variable strength; four spiral whorls flat sided; fourth whorl marked by 10 nodes; suture wavy, indistinct; body-whorl square shouldered, decorated by three rows, about 13 to each row on upper half, lower row of lesser strength than others; canal short, twisted backward; a prominent siphonal fasciole present; inner lip marked by about 10 indefinite lirations; inside of outer lip grooved to match the more prominent interspaces.

No varix appears on the type or cotype or on a representative of this species from the Oligocene of Pittsburg, Oregon, which distinguishes it readily from *G. tuberculata* (Gabb), and *G. marysvillensis* Dickerson, both from the Tejon Eocene of the Pacific Coast.

*Dimensions*:—Length of broken type, 15 mm.

*Type*:—No. 419, cotype 420, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Dr. William Healy Dall, Honorary Curator of Mollusca, Smithsonian Institution.

***Triforis martini*, new species**

Pl. 30, Fig. 9

Shell, elongate-conic, with eight slightly convex whorls; whorls decorated by three rows formed by the crossing of three strong spiral lines and about 16 axial ribs which are

parallel to the axis; one beaded intercalary thread with small beads twice as numerous nodes occurs in addition; suture wavy, indistinct, canal short.

*Dimensions*.—Length, 13 mm.; width of body-whorl, 3 mm.

*Type*.—No. 421, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Mr. Bruce Martin, who collected the type specimen.

#### ***Molopophorus stephensi*, new species**

Pl. 30, Figs. 10a and 10b

Shell small, rugose, solid with four whorls; nuclear whorls smooth, large; third and fourth whorls characteristically marked by nodose collar which is definitely set off by a rounded groove from the lower portion of the whorl; third and fourth whorls decorated by 12 sharp axial ribs crossed by equally spaced spiral threads; suture wavy, sunken; canal short, recurved with strong siphonal fasciole.

The young individual figured has about 18 slightly sinuous axial ribs instead of 12.

*Dimensions*.—Length, 13 mm.; width of body-whorl, 8 mm.

*Type*.—No. 422, cotype 423, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Dr. L. P. Stephenson of the U. S. Geological Survey.

#### ***Strepsidura packi*, new species**

Pl. 30, Figs. 11a and 11b

Shell fusiform, with seven whorls; the first four naticoid; the fifth and sixth whorls decorated by about 12 pointed nodes located medially and marking a prominent shoulder; a flat sutural band is found just beneath suture on last three whorls; space between sutural band and nodes covered by undulating spiral threads, two on fifth, six on sixth, nine on body whorl; space between suture and nodes similarly decorated; body whorl large, being two-thirds of shell length, marked by three rows

of equally spaced nodes, the uppermost, the most prominent and lowermost, the weakest; further decoration consisting of numerous spiral threads cut by growth lines; aperture oval; columella slightly incrustated; canal twisted, short.

This form differs from *Strepsidura washingtonensis* Weaver and *S. oregonensis* Dall in that it is more elongate and its shoulders on its whorls are more sloping above and less prominent.

*Dimensions*:—Length of type, 29 mm.; width of body whorl, 18 mm.

*Type*:—No. 425, cotype 424, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Mr. Robert Pack, Paleontologist, U. S. Geological Survey.

#### ***Littorina oligocenica*, new species**

Pl. 31, Fig. 1

Shell minute with five whorls; whorls nearly flat, suture distinct, linear; body-whorl about two-thirds the shell length; mouth rounded; outer lip thin.

*Dimensions*:—Length, 3 mm.; width of body-whorl, 1 mm.

*Type*:—No. 426, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

#### ***Marginella pacifica*, new species**

Pl. 31, Fig. 2

Shell minute, egg shaped, smooth; whorls four; spire nearly immersed; suture obscure; body-whorl thickest in middle; outer lip slightly thickened; inner lip bearing five sub-equally spaced plaits, of which the last two are the strongest; canal, short, wide. This form is very numerous at the type locality.

*Dimensions*:—Length, 3 mm.; width of body-whorl, 1.7 mm.

*Type*:—No. 427, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

**Fusinus gesteri**, new species

Pl. 31, Fig. 4

Shell with six and a half whorls; the first three elevated, smooth, with but slight convexity; fourth and fifth whorls decorated by about 10 wavy, equally spaced spiral lines crossed by 10 sinuous axial ribs; body-whorl with axial ribs covering upper third of shell; the lower portion being covered by spiral lines only; aperture constricted medially; inner lip but slightly calloused.

*Dimensions*:—Length, 14 mm.; width of body-whorl, 6 mm.

*Type*:—No. 429, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Mr. Clark Gester.

**Conus ruckmani**, new species

Pl. 31, Figs. 6a and 6b

Shell small with six whorls; surface of each whorl between wavy, linear suture and shoulder, concave and marked by three or four spiral threads cut by numerous, crescentric growth lines; 18 to 24 rounded nodes decorating shoulder whorls; body-whorl marked by about 20 granular spiral ribs.

*Dimensions*:—Length, 12.5 mm.; width of body-whorl, 7 mm.

*Type*:—No. 431, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named in honor of Mr. John Ruckman, whose careful work demonstrated the Oligocene age of at least the upper portion of the white shales of the Coalinga region.

**Eulima clarki**, new species

Pl. 31, Fig. 8

Shell minute with nine whorls; first three whorls naticoid; others slightly convex with linear distinct suture and two ob-

scure spiral threads on fourth and fifth whorls; aperture sub-quadrate; outer lip thin.

*Dimensions*.:—Length, 4 mm.; width of body-whorl, 1 mm.

*Type*.:—No. 433, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Dr. B. L. Clark, Instructor in Paleontology, University of California, whose recognition of the *Agasoma gravidum* zone as Oligocene has been of great service to the stratigrapher and paleontologist.

### ***Seraphs andersoni*, new species**

Pl. 31, Figs. 9a and 9b

Shell, smooth, spindle form, with five whorls; the body-whorl swollen and five times as long as spire; spire whorls nearly flat-sided; suture linear; outer lip, thin, sharp; aperture elongate, narrow; canal short, slightly twisted toward the rear.

This form is less elongate than *Seraphs erraticus* (Cooper) from the Tejon Eocene of California and the body-whorl is much wider.

*Dimensions*.:—Length, 38 mm.; width of body-whorl, 11 mm.

*Type*.:—No. 434, and cotype No. 435, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Mr. F. M. Anderson, who collected this species at its type locality.

### ***Hipponyx arnoldi*, new species**

Pl. 31, Figs. 10a, 10b, 10c and 10d

Shell oval, low with anterior meeting dorsal surface at an acute angle at apex; growth stages very prominently marked by shingle-like edges of the successive margins; a great number



of very fine radial lines roughly alternating in size further decorate the shell.

This form is much more depressed than *H. ornata*, new species from same locality and its decoration is very different.

*Dimensions*.—Length, 13 mm. ; height, 3.5 mm.

*Type*.—No. 436, cotype 437, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

Named for Dr. Ralph Arnold, who first described and recognized the Oligocene strata of Washington.

### ***Hipponyx ornata*, new species**

Plate 31, Figs. 12a and 12b

Shell with high apex bent forward so that it distinctly overhangs anterior; anterior end is vertical; posterior slope meeting base at an angle of about 30 degrees; very numerous, sub-equal rounded radial ribs which become nodose at junction with concentric growth lines forming principal decoration.

*Dimensions*.—Length, 10.5 mm. ; height, 5 mm.

*Type*.—No. 439, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

### ***Acmaea simplex*, new species**

Pl. 31, Figs. 11a and 11b

Shell, small, high, smooth except for concentric growth lines, with apex at one-third of length from anterior end; anterior, with very steep slope. This form is very similar to, or identical with, a small species found in some limestones at the head of San Lorenzo River in Santa Cruz County.

*Dimensions*.—Length, 6 mm. ; height, 3.5 mm.

*Type*.—No. 438, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, just back of the Greco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.

**Patella subquadrata**, new species

Pl. 31, Figs. 13a and 13b

Shell of moderate height, broad, marked by low rounded, obscure radial ribs with shallow interspaces only half as wide as ribs; apex two-fifths of shell length from anterior.

This form is fairly abundant at its type locality.

*Dimensions*:—Length, 6.5 mm.; height, 3.5 mm.

*Type*:—No. 440, Cal. Acad. Sci. Locality 181, near Vader, Lewis County, Washington, on east bank of the Cowlitz River, just back of the Greeco ranch house, about four miles east of Vader. Colls., F. M. Anderson and Bruce Martin.